Supernovae and GRBs powered by hot neutrino-cooled coronae

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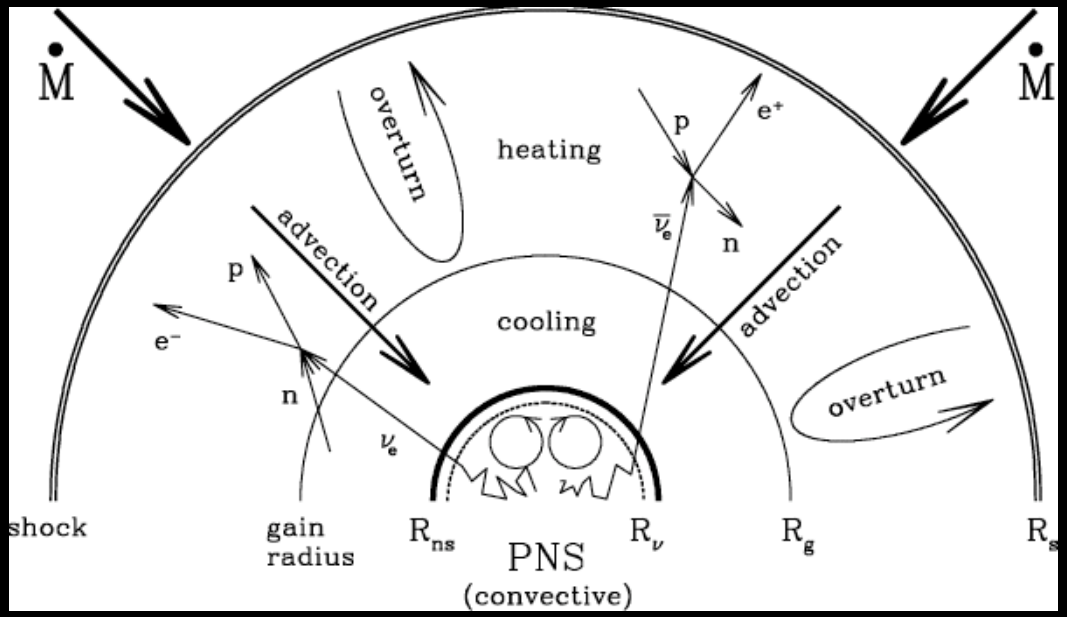
OUTLINE

- Motivation SNe and GRBs
  - overview of ν-driven mechanism
- the basic idea: coronal-powered explosions
- phenomenological motivation
- summary

ν-DRIVEN SNe AND GRBs



from Janka 2001

$$3k_BT \sim \langle E_\nu \rangle \sim 10\text{MeV}$$

$$R_\nu \sim 50\,\text{km}$$

$$E_{\text{SN}} \sim E_{\text{kin}} \sim 10^{51}\,\text{erg}$$

$$E_{\text{grav}} \sim 3 \times 10^{53}\,\text{erg}$$

REQUIRES $\sim 1\%$ EFFICIENCY

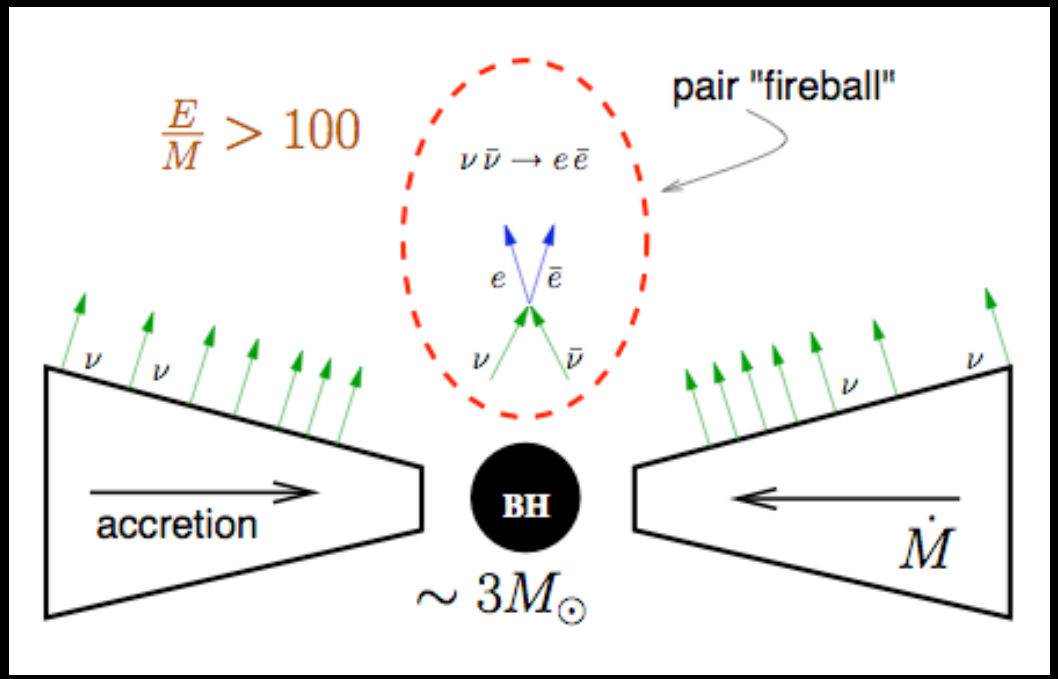
$$3k_BT \sim \langle E_\nu \rangle \sim 10\text{MeV}$$

$$R_\nu \sim 30 \left(\frac{M_{\text{BH}}}{3M_\odot}\right) \left(\frac{0.1}{\epsilon}\right) \text{km}$$

$$E_{\text{GRB}} \sim E_{\text{kin}} \sim 10^{51}\text{erg}$$

$$E_{\text{grav}} \sim 3 \times 10^{53} \left(\frac{\epsilon}{0.1}\right) \left(\frac{M_d}{M_\odot}\right) \text{erg}$$

REQUIRES $\sim 1\%$ EFFICIENCY



NOTE:

ν-driven mechanisms for both SNe and GRBs assume that gravitational binding energy is dissipated locally i.e.,

$$\epsilon_{\rm grav}\left(z\right) \propto \rho\left(z\right)$$

as in the case of Kelvin-Helmoltz contraction and Shakura-Sunyaev -like accretion i.e.,

GRAVITATIONAL POWER=THERMAL RADIATION

BASIC IDEA: ADD A CORONA

SNe/PNS	GRBs/HED
$\nu_e + n \rightarrow e + p$ $\bar{\nu_e} + p \rightarrow \bar{e} + n$ $Q^+_{\nu\, N} \sim \sigma_0 Y_N n_B \frac{L_\nu}{A} \langle E^2_\nu \rangle$	$\nu + \bar{\nu} \rightarrow e + \bar{e}$ $Q^+_{\nu,\bar{\nu}} \sim \sigma_0 \frac{L^2_\nu}{A^2} \langle E_\nu \rangle$

Q^+ ASSUMES ITS LOWEST VALUE IF THE ν -SOURCE IS A BLACKBODY, SINCE FOR A FIXED L_ν, BLACKBODIES MINIMIZE $\langle E_\nu \rangle$.

$\longrightarrow$ *introduce a corona* $\longleftarrow$

FROM ABOVE, A CORONA MAY BE ENERGETICALLY SUBDOMINANT IN TERMS OF ENERGY RELEASE, BUT CAN STILL DOMINATE THE ENERGY DEPOSITION...

"Add" a corona

neutrino energy deposition rate goes like

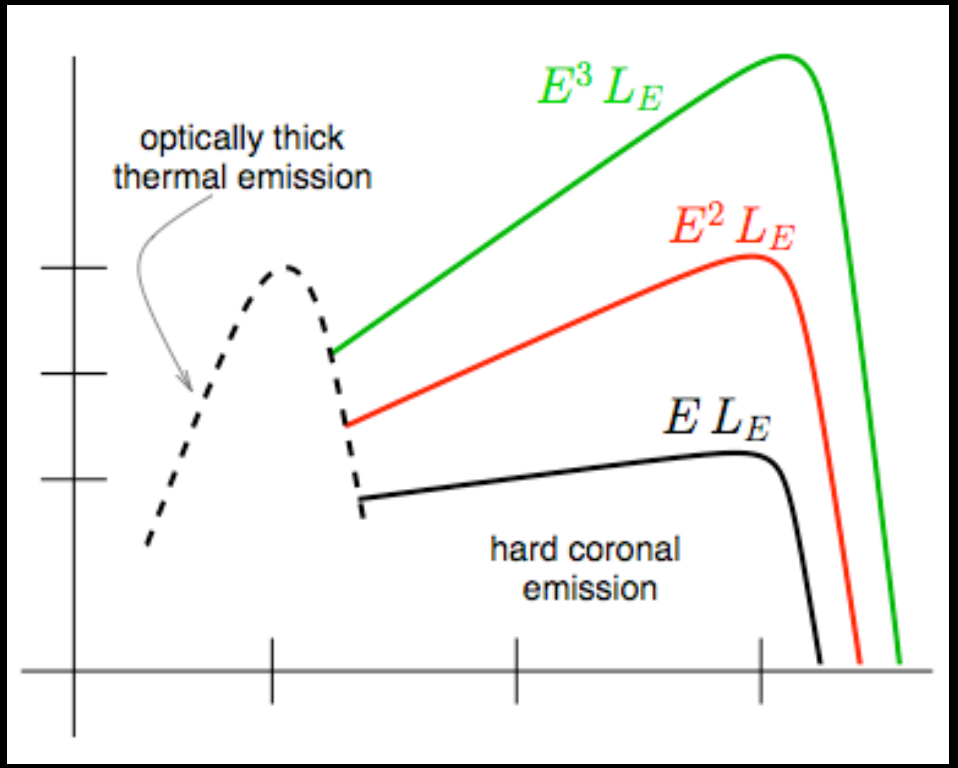
$$Q_\nu^+ \propto L_\nu \langle E_\nu^n \rangle = L_\nu^{\rm soft} \langle E_\nu^n \rangle_{\rm soft} + L_\nu^{\rm hard} \langle E_\nu^n \rangle_{\rm hard}$$

$n = 1$ for $\nu + \bar{\nu} \longrightarrow e + \bar{e}$

for the hyper-eddington disk GRB model

$n = 2$ for $\nu + N \longrightarrow \beta + N'$

for the proto-neutron star SNe model



moral an energetically subdominant corona can dominate the deposition. The reason:

$$\sigma_\nu \propto E_\nu^2$$

PHENOMENOLOGICAL MOTIVATION

question: WHAT DO WE KNOW ABOUT ACCRETION ONTO STELLAR MASS BLACK HOLES? I.E., BLACK HOLE X-RAY BINARIES (BHXRBS)

Black Holes in Binary Systems. Observational Appearance

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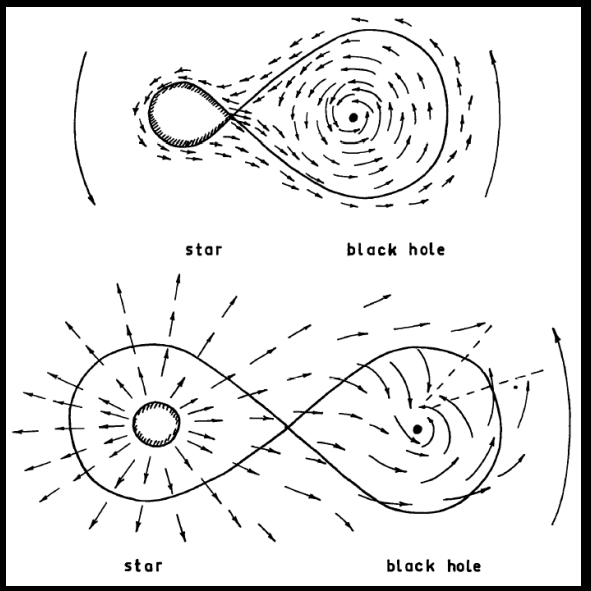
Received June 6, 1972

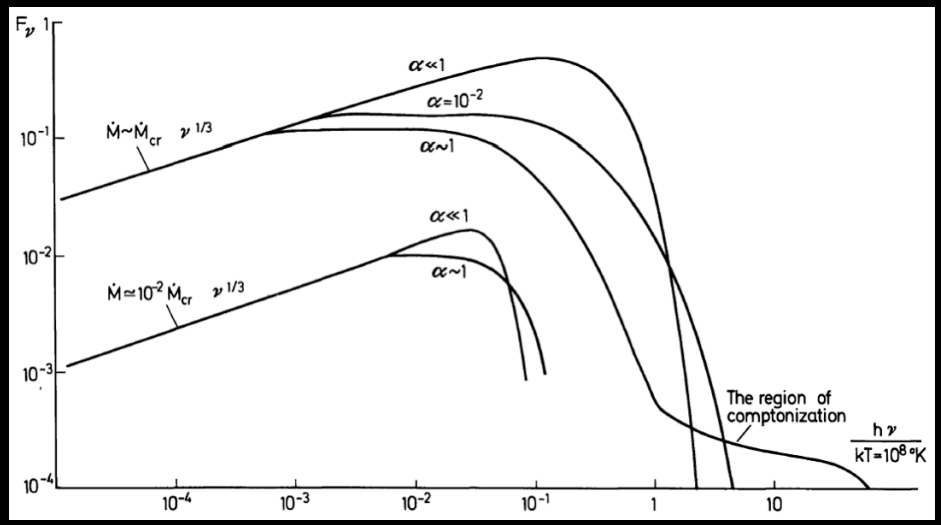


TWO MOST IMPORTANT ASSUMPTIONS

$$\tau_{\mathrm{R}\phi} \sim \alpha P$$

$$H_d \tau_{r\phi} \frac{d\Omega}{d\ln r} = F^+ \simeq \sigma T_{eff}^4$$

LOCAL DISSIPATION OF BINDING ENERGY LEADS TO THERMAL ~ BLACK BODY SPECTRA.



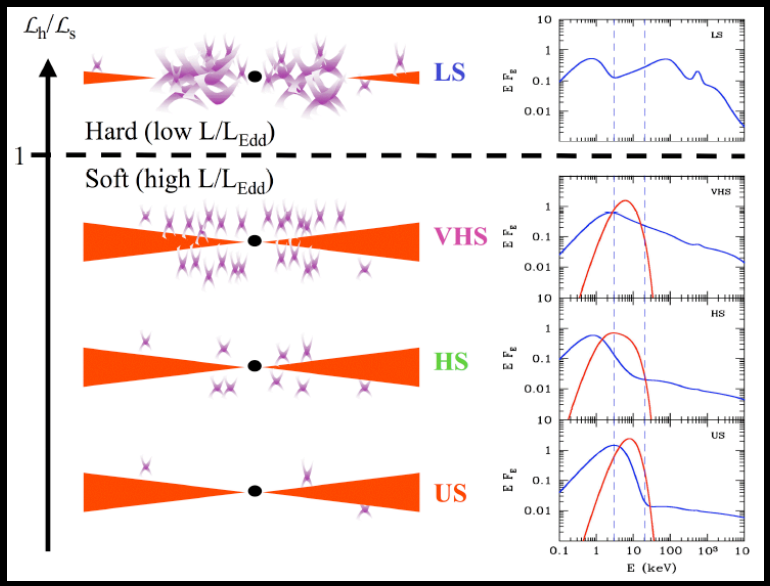
Done & Gierlinski 2004

CORONAE IN BHXRBs

CLEARLY, THE ACT OF ACCRETION ONTO A BLACK HOLE DOES NOT OBEY LOCAL DISSIPATION.

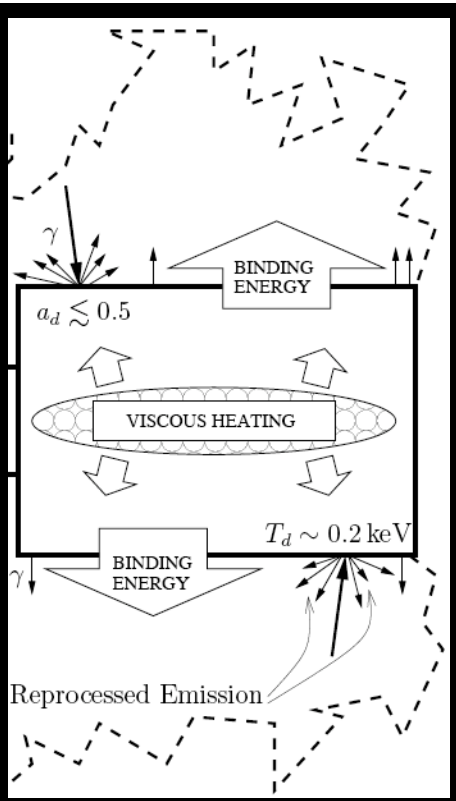
THE RATIO OF HARD TO SOFT EMISSION

$$\frac{L^{\rm hard}}{L^{\rm soft}} \sim 1 - 100\%$$



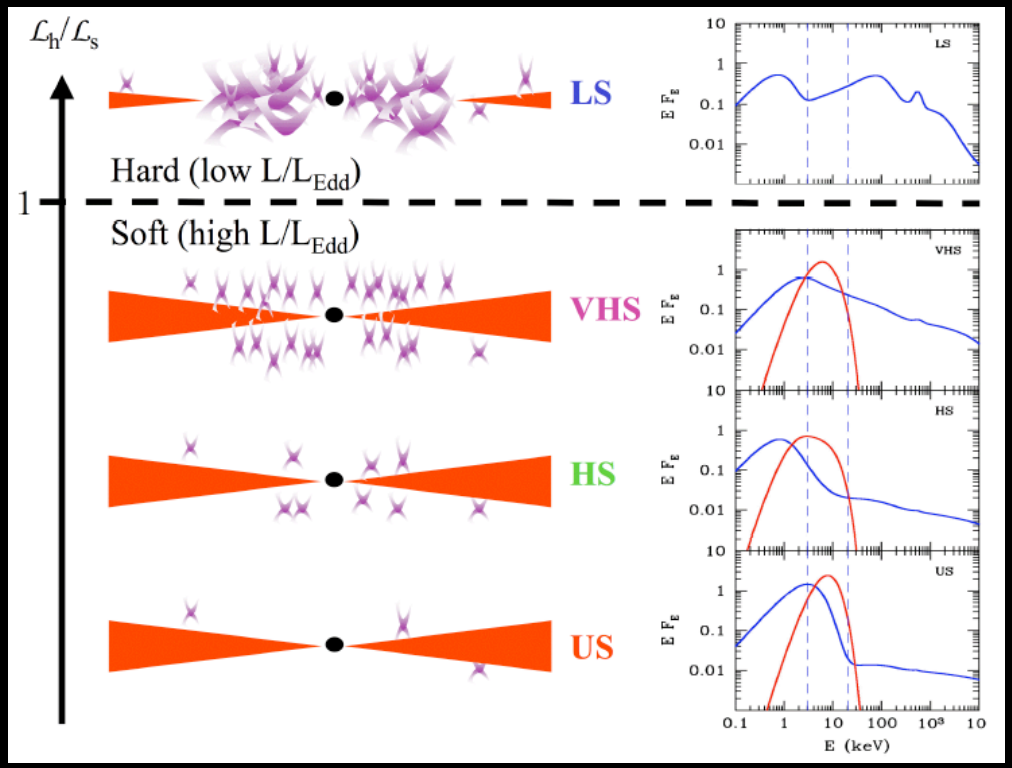
question WHY IS SO MUCH OF THE ACCRETION POWER RELEASED OUTSIDE OF THE FLOW?

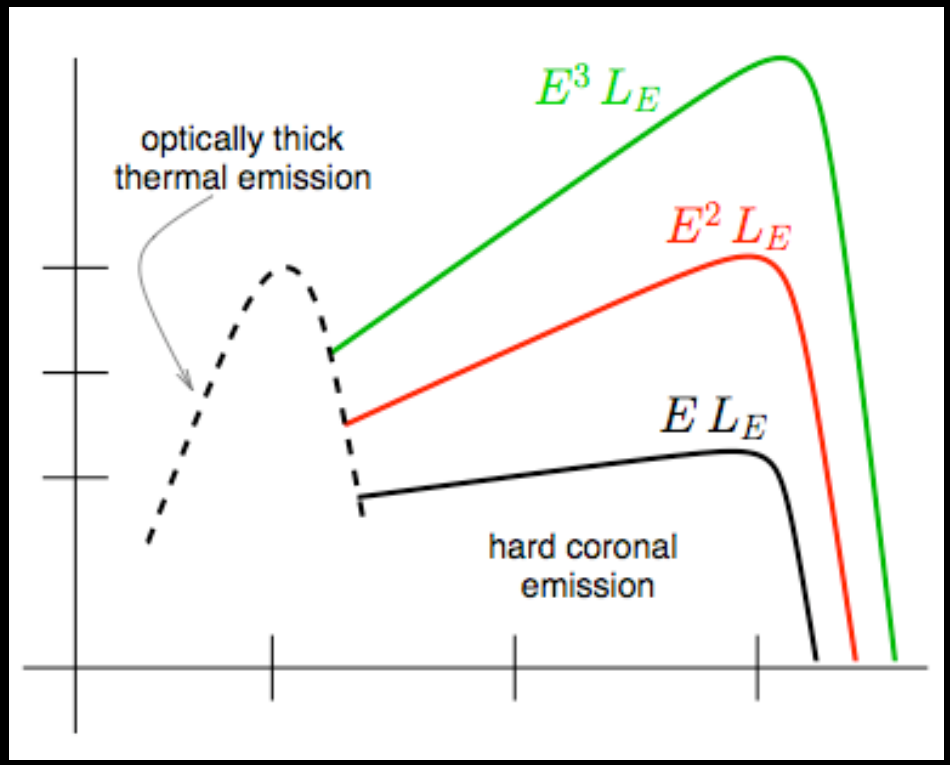
PERHAPS MAGNETIC BOUYANCY (RESULTING FROM MRI TURBULENCE) OR WAVES OF SOME SORT CAN TRANSPORT RANDOMIZED BINDING ENERGY AT THIS RATE. THESE IDEAS ARE OLD AND COME FROM OBSERVATIONS OF THE CHROMOSPHERE AND CORONA OF THE SUN. BUT, NOBODY REALLY KNOWS WHAT THE MECHANISM ACTUALLY IS. HOWEVER, IN NATURE, POWERFUL CORONAE ARE UBIQUITOUS IN BLACK HOLE (& NEUTRON STAR) ACCRETION FLOWS.



EFFECT ON ENERGY DEPOSITION

$$Q_\nu^+ \propto L_\nu \langle E_\nu^n \rangle = L_\nu^{\text{soft}} \langle E_\nu^n \rangle_{\text{soft}} + L_\nu^{\text{hard}} \langle E_\nu^n \rangle_{\text{hard}}$$





IF THE RELATIVISTIC TURBULENT CENTRAL ENGINES OF SNE AND GRBS BEHAVE LIKE RELATIVISTIC TURBULENT CENTRAL ENGINES THAT WE CAN ACTUALLY OBSERVE, THEN THE BASIC APPROACH TO MODELING CORE-COLLAPSE ENVIRONMENTS HAS TO CHANGE.